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A Urban vector potentiality of *Anopheles stephensi* in Vijayawada, Krishna District of Andhra Pradesh, India

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Abstract: Malaria is the major health problem in coastal Andhra Pradesh, yet its transmission dynamics is not served properly. The present investigations reveal the prevalence of quantitative aspects of *Anopheline* species in the study area. A longitudinal study was carried out from July 2008 to June 2009 in the urban areas of Vijayawada city to understand the vector potentiality. The study of urban malaria vector potentiality was conducted on 24,216 population consisting of 6,755 households. Overall 15 study areas (3 posh areas, 3 mixed areas, 3 slum areas, 3 low lying areas and 3 hilly areas) were selected for survey. The larval count and the container adult breeding was calculated in terms of container index (CI), house index (HI) and breteau index (BI) and as breeding preference ratio (BPR). *Anopheles stephensi* showed high larval density and high man hour density (32.68%) in October 2008 (probably due to heavy rains) confirms the presence of favourable malariogenic conditions. *A. stephensi* is the successful vector in the studied urban area.

Keywords: *Urban malaria vector, Anopheles stephensi, Vijayawada.*

I. Introduction

Malaria is endemic in more than 100 countries and less than 40 per cent of the world's population is at risk of malaria (World Malaria Report, 2008). Malaria is considered to be a major hazard out of all the diseases which damage the public health in India. Malaria is found in almost all the parts of India except in the areas of about two thousand meters altitude and in some coastal belt; particularly malaria is manifested in the temperate zone. Annually 100 million people are affected by malaria and about 1.5 to 2.7 million persons are found to be killed by the disease worldwide (WHO, 1993). There are 37 mosquito generae in the world and are broadly divided into *Anophelines* (3 generae), *Culicines* (33 generae) and *Toxorhynchitis* (one genus) (Kumar, 1996). Approximately 3,500 species of mosquitoes grouped in 41 genera. Of the approximately 430 *Anopheles* species, only 30-40 species transmit malaria in nature (Center for Disease Control and Prevention, Sep 7th 2004). In India, there are 9 *Anopheles* mosquito species which are held responsible for transmission of malaria (Rama Chandra Rao *et al.*, 1984).

Anopheline mosquitoes live in tropical and subtropical regions and in temperate climates (even in the summer). Among the 9 mosquito species, *Anopheles culicifacies*, *A. fluviatilis* and *A. stephensi* are reported to be successful vectors in Andhra Pradesh. In rural areas, malaria is found to be transmitted by *A. culicifacies*, in urban areas by *A. stephensi* and in forest hilly areas by *A. fluviatilis*. Vinod Joshi *et al*., (2005) studied the occurrence of *Anopheles* species in irrigated and non-irrigated areas of Thar dissert, Rajasthan. Entomological studies showed the prevalence of *A. stephensi* in all the three seasons. *A. stephensi* is regarded as the major urban malaria vector (Vinod Joshi, *et al*., 2005). The magnitude of malaria was more among people of backward community than in the forward community in Rajasthan (Yadav *et al*., 2005). Climatic variables and malaria incidence in Dehradoon, Uttaranchal (India) revealed that climatic variables that predict the presence or absence of malaria are likely to be the best suited for forecasting the distribution of this disease at the edges of fits range (Pemola Devi and Jauhari, 2006). Prevalence of large number and species of *Anopheline* mosquitoes in the forest area of Nigeria may be associated with the availability of aquatic breeding sites (Oyewole *et al*., 2006).

The mosquito larval habitats were seepage pools, river beds, rice fields, tanks, forest pools, ditches, streams, rock holes, tree holes, intradomestic containers and shallow pits in western Himalayas of Garhwal region (Pemola Devei and

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Jauhari, 2007). Investigations on the resting preference of mosquito species in wells in Vellore in Tamilnadu revealed that microclimate along the inner walls of wells provided very congenial resting place to mosquitoes (Rajagopal *et al.*, 2010). Use of insecticides treated long-lasting bed nets act as protective measure to reduce the vector species in Panaji, Goa (Kaliwal *et al.*, 2010). Extracts of *Calotropis procera* possess good larvicidal activity against mosquitoes (Shahi *et al.*, 2010).

To know the causes of perennial transmission, the area of Vijayawada is selected as it is surrounded by hilly areas and low lying areas and consists of over head tanks, cement tubs, water drums, municipal drains with full of breeding sources. The study area of the city is having completely urban atmosphere. Of all the vector borne diseases, malaria is found to be a dreadful epidemic disease. Hence, a new vista has been opened to study the incidence of Urban Malaria and vector potentiality of *A. stephensi* in Vijayawada (nearly 20% of the Vijayawada population is at the risk of malaria).

II. Material & Methods

The present survey was conducted with weekly intervals from July 2008 to June 2009. The study area located in and around the hilly areas, and the riverine belt of river Krishna (surrounding Vijayawada in one side of entire city). Vijayawada is surrounded by hills and hillocks with temperature fluctuations in between 30º C to 38° C and some times 40° C in last week of May. Rainfall is moderate with relative humidity, 60-66%. Vijayawada is accounting automobile engineering workers (Autonagar), cosmopolitan people, new building constructions, Mission (Jawaharlal Nehru National Urban Renewal Mission [JNNURM]) and the development of the fast track city. The streets dug for under ground drains have become the favourable sites particularly in rainy season for mosquito breeding.

Population in the study area: The study was conducted in 15 localities. Blood smears were collected from fever patients. Vector and larval collection was made in randomly selected posh area (3 localities), mixed area (3 localities), slum area (3 localities), low lying area (3 localities) and hilly area (3 localities) basing upon type of housing, general hygiene, sanitation and living standards of the residents (Table 1). The study area surrounds the hilly area (Mogulrajpuram), and low lying area of (Krishnalanka) which is adjacent to the bank of river Krishna.

Collection of adult mosquitoes and larvae: Adult and larval collection of vector were made from fixed and random catching stations at monthly intervals from July 2008 to June 2009. Adult *Anopheles* mosquitoes were collected from both fixed and random catching stations during night hours (5:00 p.m. to 11:00 p.m.) in 6 houses spending 15 minutes in each house. Aspirators and flash lights were used during night hours. Adult mosquitoes were collected thrice a week every month so as to cover 24 catching stations in every day in two areas. Collected mosquitoes were brought to the laboratory and anesthetised and identified up to species level following standard identification keys (Barred, 1934; Das and Kaul, 1998). The potential breeding habitats in the study area in each locality were screened in every month as per the guidelines given by WHO (1975). Flash light, wide mouthed pipettes, larval dippers of 300 ml capacity and well nets were used to collect the larvae. The data of larval count was analysed and calculated in terms of container index (CI), house index (HI) and breteau index (BI) following the method of Service, (1976). The container adult breeding was assessed by calculation of breeding preference ratio (BPR).

Larval collection: Ladles were used to collect the mosquito larvae. Five to ten ladle dips were collected from each breeding place depending upon the size of the breeding source and the average was recorded (Operational manual NFCP, Delhi, 1995). Large breeding places have chosen for collecting developmental stages at two or more points. Hundred breeding places were conveniently checked per day. The average larval and pupal density was estimated as given below:

$$\text{Larval density} = \frac{\text{Total no. of larvae collected}}{\text{Total no. of dips taken}}$$

Adult mosquito collection: The collection was made from each of six houses for fifteen minutes between 5:00 p.m. to 11:00 p.m. The mosquitoes collected were counted, identified and recorded. The criteria for the calculation of vector density are total number of mosquitoes collected and the total time (in hours) spent for collection.

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The average vector density was calculated as given below:

$$\text{Vector density} = \frac{\text{No. of Anopheline mosquitoes collected}}{\text{Time (in hours) spent on mosquito collection}}$$

When vector density is less than 50, it can be identified as low vector density. When it is in between 50 and 83, it can be identified as medium and when it is more than 83, it can be identified as high density.

Vector infection and infectivity rates: Development of infective stages depends on the physiological and genetical factors of a vector host and environmental factors. Mosquitoes contain developing and developed forms (gametocyte forms of parasite). Sporozoite stage of parasite determines the malaria transmission potential. All female Anopheline mosquitoes are dissected to determine the parasite infection. The vector infection and infectivity rate were calculated as given below:

$$\text{Vector infection rate} = \frac{\text{No. of female vectors having gametocytic stages}}{\text{No. of female mosquitoes dissected}}$$

$$\text{Vector infectivity rate} = \frac{\text{No. of female vectors having sporozoite stages}}{\text{No. of female mosquitoes dissected}}$$

The malaria epidemiological situation was determined following malariometric indices.

Sample size: Data on the prevalence of malaria was available from the survey in five areas of fifteen localities in Vijayawada city (from the Annual report of District Malaria Camp Office, Vijayawada, 2009). These surveys reported the high prevalence of malaria and vector potentiality of *A. stephensi*. The population in Vijayawada was 10 lakhs as per census of India, 2001. The study of urban malaria and vector potentiality was conducted on 24,216 population consisting of 6,755 households. The average number of persons in a family is approximately 4 (3.58%).

Sampling design: The number of households surveyed were 6755.

III. Results

People living in slum locality are experiencing high malarial positive cases. Their housing pattern, living standards, socio-economical problems, poor sanitation, and lack of proper health education may be playing a significant role for transmission of malaria. Man mosquito contact is favoured by housing pattern in this surveyed area. During the transmission period of malaria, there was no disease prevalence in May 2009 in all the localities of study area. Many breeding places like municipal drains, overhead tanks, desert water coolers, flower pots, ditches in rainy season, cement tubs, water drums, waste tyres, discarded buckets, discarded earthen pots, traditional mortars, and coconut shells are contributing to the occurrence of malaria (Table 2).

Studies on the prevalence of *A. stephensi* in posh, mixed, slum, low lying and hilly areas showed different House Index (HI), Container Index (CI), and Breatue Index (BI) (Table 3). The HI, CI and BI were calculated following the guidelines of WHO (2003). The HI % was 34.5, CI % was 13.5 and BI % was 36.2 in posh area. In mixed area, the HI% was 21.5, CI % was 8.8, and BI % was 21.5 and in slum area the HI % was 11.7, CI % was 8.1 and BI % was 18.0. In low lying area, the HI% was 24.5, CI % was 14.7 and BI % was 31.1 and in hilly area the HI % was 15.8, CI % was 14.0 and BI % was 41.8.

The BPR of *Anopheles* larvae was 0.60 in municipal drains, 1.99 in over head tanks, 0.64 in desert water coolers, 0.57 in flower pots, 0.65 in ditches, 0.12 in cement tubs, 1.05 in water drums, 0.93 in waste tyres, 1.13 in discarded buckets,

0.51 in discarded earthen pots, 0.87 in traditional mortars and 0.62 in coconut shells in rainy season. The larval density of *Anopheles* showed much variation in rainy, winter and summer seasons in different posh areas, mixed areas, slum areas, low lying areas and hilly areas during the study period. Comparatively the larval density was less in summer season in all the places of surveyed area (Table 5). The larval density was found to be maximum in rainy season and minimum in summer season in posh, mixed, slum, low lying and hilly areas (Table 6). Interestingly, it was found that the density of larvae was maximum in posh area when compared to mixed, low lying and hilly area. In May 2009, the larval indices of *Anopheles* species was recorded 0% in hilly area. The seasonal variation (month-wise) in Vector Man Hour Density (MHD) of *A. stephensi* is shown in Table 7.

The Vector *A. stephensi* MHD showed much variation in rainy, winter and summer seasons in different posh areas, mixed areas, slum areas, low lying areas and hilly areas during the study period. Comparatively the MHD of male and female *A. stephensi* was less in summer season in all the surveyed areas during May 2009 (posh area 1.61, mixed area 1.62, slum area 1.28, low lying 2.03 and hilly area 1.71). Similarly in rainy season (in October, 2008), the vector MHD was high in of posh (28.55%), mixed (24.44%), slum (20.20%), low lying area (32.685) and hilly (24.35%) areas. Low vector MHD was recorded in slum area (1.28%), and the highest mosquito density was recorded in low lying area (32.68) during rainy season (July, 2008 to October, 2008).

The total vector MHD during the study period is shown in Table 11. The vector mosquito density was found to be maximum (636) in October 2008 (rainy season) and minimum (40) in May 2009 (summer season). Similarly, the Man Hour Density was found to be maximum (159.00) in October 2008 and minimum (10.00) in May 2009.

IV. Discussion

The Andhra Pradesh State on the Indian cost is endemic for malaria for decades. About 50% of the world population lives in endemic areas of malaria (WHO, 1994). The differences in the climate and ecology of the environment and the human activities are responsible for the prevalence of malaria. The tremendous ecological changes also led to drastic changes in vector densities as well as species distribution; some of the parasitic larvae shifted their habitat to water reservoirs. Exploitation of natural resources, unplanned urbanisation, deforestation, human activities etc. altered the ecosystem and behaviour of vectors affecting malaria transmission. Increased population in urban area has major implication for malaria epidemiology both in terms of vector density and host – vector contact resulting in malaria transmission.

The housing and clothing pattern of people living in urban area are conducive. Inadequate epidemiological surveillance and/or incomplete treatment are some of the major constraints for reducing and/or eliminating the disease. From the observations of the present study, it may be concluded that the examination of peripheral blood smears is the reliable method for the detection of malarial parasites in the diagnosis of malaria. Spielman (1988) and Shankar *et al*., (2004) also suggested that the microscopic examination of peripheral blood smear is to be considered as a reliable method for detecting malaria in endemic areas all over the world.

Careful examination of indoor and outdoor households revealed the adult mosquitoes and habitats. The water in pools and in the containers was reported to be brackish in nature (Pandian *et al*., 1997). Rain water which lasts for 7 to 8 days in small pits and damaged road sites become the favourable place for mosquito breeding as suggested by Corbet (1961) and house hold materials like pots, traditional mortars and coconut shells left undisturbed filled with rain water or other water are also selected as the breeding places for mosquitoes. Several such habitats and/or mosquitogenic places were identified during the survey period.

The collection of immature, larval and pupal stages of mosquitoes and adult vectors from indoor and outdoors also confirm the presence and occurrence of vector hosts and /or the favourable conditions for breeding of mosquitoes. The over head tanks (30.7%), cement tubs (17.3%), water drums (15.3%), discarded earthen pots (7.0%), ditches in rainy season (5.2%), municipal drains, flower pots and discarded buckets (4.2%), waste tyres (4.0%), desert water coolers (3.5%), traditional mortars (2.1%) and coconut shells (1.7%) are the main sources for the favourable breeding place for vector hosts (Table 2). The larvae and adult mosquitoes collected at different households during the present survey period were identified up to species level. Adult *A. stephensi* was found in posh, mixed, slum, low lying and hilly area. This particular species

showed high density in low lying area (32.68%) and low density in slum area (20.20%). Detailed entomological studies revealed that the occurrence of *A. stephensi* in all the localities of study area was more in rainy season. Pemola Devi and Jauhari (2006) also reported high density of *A. stephensi* in rainy season in Kalsi area of Dehradun (January 2001 to December 2002). It is suggested that mosquito control programmers should be operated effectively before the onset of rains as malaria prevalence is high in rainy season in the study area. Also, people should be advised to use mosquito repellents, destroy mosquitoes and take care of the mosquito breeding sites.

The correlation between vector density (*A. stephensi*) and monthly parasite occurrence was higher in rainy season followed by winter season and summer season. It is suggested that with the high density of *A. stephensi* there was an increase in malaria positive cases. Pemola Devi and Jauhari (2006) also found a correlation between high density of *A. stephensi* and the high prevalence of malaria in Kalsi area of Dehradun. It is clear from these observations that the mosquito population in the Vijayawada urban area (study area) showed variation in their number; the abundance of vector host may be mainly due to favourable mosquitogenic conditions created by the people living there. The persistence of malaria throughout the year can be eliminated by the total elimination of mosquitogenic factors there by controlling the population of vector hosts.

Our epidemiological data on malaria prevalence, supported by the entomological observations suggest that transmission of malaria in the study area was seasonal and found between July 2008 to February 2009 (during both rainy and winter seasons). However, malaria cases were also detected during the dry months (March 2009 to June 2009). Our data is similar to that of Mehrunnisa *et al*., (2000) who reported low prevalence of malaria from January to April 1999. The occurrence of abundant number of *A. stephensi* in rainy season in the study area is useful to understand the density of vector population. The ecology and population dynamics in addition to the prevalence, distribution and species composition of various vector mosquitoes are helpful to study the behaviour and biology of mosquitoes as reported by Urmila *et al*., (1999).

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Table 1. Demographic details of the study area and income levels of the sampled inhabitants

Area	Locality	No. of Families	Total Population	Income Levels (Rs.)
Posh	Brindavan Colony	650	2120	2.5-3.0 Lakhs
	Tikkle Road	485	1675	
	Bank Colony	550	1774	
Mixed	P&T Quarters	550	1853	1.5-2.0 Lakhs
	Pragathi Nagar	340	1160	
	Israel Pet	373	1283	
Slum	Petingle Pet (Vallurupurnachandra Rao Huts)	531	1893	12,000-75,000
	Behind Greenland Hotel	427	1793	
	Swargapuri Road	553	1759	
Low lying	Phakirgudem	408	1753	1.0-1.25 Lakhs
	Ranigarithota	482	1784	
	Ranadheernagar	510	1879	
Hilly	Gummadivari street	311	1264	0.75-1.25 Lakhs
	Balabhaskarnagar	299	1175	
	Chandra Rajeswarnagar	286	1051	
	TOTAL	**6,755**	**24,216**	

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Table 2. Details of the factors contributing to the growth of incidence of malaria

Locality	FACTORS* CONTRIBUTING TO THE GROWTH OF INCIDENCE OF MALARIAL FEVER											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Brindavan Colony (5)	+	+	+	+	x	x	+	x	x	x	x	x
Tikkle Road (6)	+	+	+	+	+	x	+	x	x	x	x	x
Bank Colony (6)	+	+	+	+	+	x	+	x	x	x	x	x
P&T Quarters (3)	x	+	+	+	x	x	x	x	x	x	x	x
Pragathinagar (7)	+	+	+	+	x	+	+	x	x	x	+	x
Israel Pet (9)	+	x	x	+	x	+	+	+	+	+	+	+
Petingle Pet (8)	x	x	x	x	+	+	+	+	+	+	+	+
Behind Greenland Hotel (6)	x	x	x	x	+	+	x	+	+	+	+	x
Swargapuri Road (9)	+	X	x	+	+	+	x	+	+	+	+	+
Phakirgudem (6)	+	X	x	x	x	+	x	+	+	+	+	x
Ranigari thota (5)	x	X	+	x	x	+	+	x	x	+	+	x
Ranadheernagar (8)	x	X	x	+	+	+	+	x	+	+	+	+
Gummadivari Street (6)	x	X	x	x	x	+	+	+	+	+	+	x
Balabhaskarnagar (9)	+	+	+	+	x	x	+	+	+	+	+	x
Chandra Rajeswarnagar (8)	x	X	x	x	+	+	+	+	+	+	+	+
Total	**8**	**6**	**7**	**9**	**7**	**10**	**11**	**8**	**9**	**10**	**11**	**5**

*1 = Municipal Drains; 2= Overhead Tanks; 3 = Desert Water Coolers; 4 = Flower Pots; 5 = Ditches in rainy season; 6 = Cement tubs; 7 = Water Drums; 8= Waste Tyres; 9 = Discarded Buckets; 10 = Discarded Earthen Pots; 11 = Traditional Mortors; 12 = Coconut shells

'+' Positive; 'x' Negative

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Table 3. Prevalence of *Anopheles stephensi* in different localities of Vijayawada city

Area	Location	No.of Houses visited		HI%	No.of Containers		CI %	BI %
		Scree-ned	Posi-tive		Scree-ned	Posi-tive		
Posh	1.Brindavan colony	122	32	26.0	293	39	13.3	31.9
	2.Tikkel Road	98	47	47.9	284	32	11.2	32.6
	3.Bank Colony	119	38	31.9	329	52	15.8	43.6
	Total	**339**	**117**	**34.5**	**906**	**123**	**13.5**	**36.2**
Mixed	1.P&T quarter	102	22	21.5	262	22	8.3	21.5
	2.Pragathi Nagar	118	34	28.8	293	24	8.1	20.3
	3.Israel Pet	137	21	15.3	317	31	9.7	22.6
	Total	**357**	**77**	**21.5**	**872**	**77**	**8.8**	**21.5**
Slum	1.Petengle pet	180	19	10.5	352	29	8.2	16.1
	2.Greenland Hotel	127	14	11.0	297	22	7.4	17.3
	3.Swargapuri Road	154	21	13.6	364	32	8.7	20.7
	Total	**461**	**54**	**11.7**	**1013**	**83**	**8.1**	**18.0**
Low lying	1.Phakeergudem	106	26	24.5	209	39	18.6	36.7
	2.Ranigarithota	120	31	25.8	286	42	14.6	35.0
	3.Ranadheer Nagar	124	29	23.3	242	28	11.5	22.5
	Total	**350**	**86**	**24.5**	**737**	**109**	**14.7**	**31.1**
Hilly	1.Gummadivari Street	83	17	20.4	239	38	15.8	45.7
	2.Balabhaskar Nagar	97	14	14.4	288	32	11.1	32.9
	3.Chendrarajeswara Nagar	85	11	12.9	264	41	15.5	48.2
	Total	**265**	**42**	**15.8**	**791**	**111**	**14.0**	**41.8**
	Grand Total	**1772**	**376**	**21.2**	**4319**	**503**	**11.6**	**28.3**

HI - House Index; CI – Container Index; BI – Breatue Index

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Table 4. Relative abundance of *Anopheles* larvae in different containers and the breeding preference

Sl. No	Type of Container	No. of Containers With Water			Breeding Preference Ratio BPR (Y/X)
		Examined (X) (%)	With *Anopheles* Larvae(Y) (%)	Total No. of Larvae	
1	Municipal drains	293 (6.9)	22 (4.2)	152	0.60
2	Over head tanks	647 (15.4)	158 (30.7)	3058	1.99
3	Desert water coolers	227 (5.4)	18 (3.5)	304	0.64
4	Flower pots	309 (7.3)	22 (4.2)	154	0.57
5	Ditches in rainy season	339 (8.0)	27 (5.2)	162	0.65
6	Cement tubs	648 (15.4)	89 (17.3)	2244	0.12
7	Water drums	611 (14.5)	79 (15.3)	1264	1.05
8	Waste tyres	182 (4.3)	21 (4.0)	171	0.93
9	Discarded Buckets	157 (3.7)	22 (4.2)	119	1.13
10	Discarded Earthen pots	569 (13.5)	36 (7.0)	684	0.51
11	Traditional Mortors	102 (2.4)	11 (2.1)	90	0.87
12	Coconut shells	117 (2.7)	9 (1.7)	54	0.62
	Total	**4,201**	**514**	**8,456**	

Note: Figures shown in the parentheses are percentages.

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Table 5. Seasonal variation of *Anopheles* larval density in house index and container index in different localities

Month and Year	Posh Area		Mixed Area		Slum Area		Low lying Area		Hilly Area	
	HI(339)	CI(906)	HI(357)	CI(872)	HI(461)	CI(1013)	HI(350)	CI(737	HI(265)	CI(791)
In rainy season:										
July 2008	12	29	7	17	8	11	10	24	8	13
August 2008	23	32	12	21	11	23	14	28	11	16
September 2008	29	43	18	25	19	28	19	31	14	18
October 2008	32	51	23	29	22	31	22	37	17	21
In winter season:										
November 2008	27	49	28	32	27	33	27	43	20	24
December 2008	23	42	21	27	21	29	23	40	17	21
January 2009	18	38	17	20	18	21	19	37	15	17
February 2009	11	30	11	16	11	17	12	31	11	11
In summer season:										
March 2009	7	21	8	14	8	13	8	29	7	8
April 2009	4	17	5	9	4	8	5	22	3	4
May 2009	2	7	2	3	2	3	4	11	0	0
June 2009	5	11	3	5	3	4	6	16	2	4
Total	**193**	**370**	**155**	**218**	**154**	**221**	**169**	**349**	**127**	**157**

HI - House Index; CI – Container Index

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Table 6. Seasonal variations in larval indices of *Anopheles sps.*

Month and year	Posh Area			Mixed Area			Slum Area			Low lying Area			Hilly Area		
	HI	CI	BI	HI	CI	BI	HI	CI	BI	HI	CI	BI	HI	CI	BI
In rainy season:															
July 2008	3.5	3.2	8.5	1.9	1.9	4.7	1.7	1.0	2.3	2.8	3.2	6.8	3.0	1.6	4.9
August 2008	6.7	3.5	9.4	3.3	2.4	5.8	2.3	2.2	4.9	4.0	3.7	8.0	4.1	2.0	6.0
September 2008	8.5	4.7	12.6	5.0	2.8	7.0	4.1	2.7	6.0	5.4	4.2	8.8	5.2	2.2	6.7
October 2008	9.4	5.6	15.0	6.4	3.3	8.1	4.7	3.0	6.7	6.2	5.0	10.5	6.4	2.6	7.9
In winter season:															
November 2008	7.9	5.4	14.4	7.8	3.6	8.9	5.8	3.2	7.1	7.7	5.8	12.2	7.5	3.0	9.0
December 2008	6.7	4.6	12.3	5.8	3.0	7.5	4.5	2.8	6.2	6.5	5.4	11.4	6.4	2.6	7.9
January 2009	5.3	4.1	11.2	4.7	2.2	5.6	3.9	2.0	4.5	5.4	5.0	10.5	5.6	2.1	6.4
February 2009	3.2	3.3	8.8	3.0	1.8	4.4	2.3	1.6	3.6	3.4	4.2	8.8	4.1	1.3	4.1
In summer season:															
March 2009	2.0	2.3	6.1	2.2	1.6	3.9	1.7	1.2	2.8	2.2	3.9	8.2	2.6	1.0	3.0
April 2009	1.1	1.8	5.0	1.4	1.0	2.5	0.8	0.7	1.7	1.4	2.9	6.2	1.1	0.5	1.5
May 2009	0.5	0.7	2.0	0.5	0.3	0.8	0.4	0.2	0.6	1.1	1.4	3.1	0	0	0
June 2009	1.4	1.2	3.2	0.8	0.5	1.4	0.6	0.3	0.8	1.7	2.1	4.5	0.7	0.5	1.5

HI- House Index, CI- Container Index, BI- Breteau Index

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Table 7. Seasonal variations in vector man hour densities of *Anopheles stephensi* in different areas of Vijayawada city

Month and Year	Posh Area			Mixed Area			Slum Area			Low lying Area			Hilly Area		
	No.of Mosquitoes		Man hour den-sity	No.of Mosquitoes		Man hour den-sity	No.of Mosquitoes		Man hour den-sity	No.of Mosquitoes		Man hour den-sity	No.of Mosquitoes		Man hour den-sity
	M	F		M	F		M	F		M	F		M	F	
In rainy season:															
July 2008	22	62	11.13	16	52	12.10	13	46	8.44	14	82	15.14	12	37	10.60
August 2008	28	94	16.87	21	78	18.15	17	65	11.93	19	113	20.86	18	54	15.47
September 2008	37	120	21.54	39	93	21.64	22	102	18.73	28	136	25.11	27	62	17.76
October 2008	48	159	28.55	42	105	24.44	38	110	20.20	32	177	32.68	32	85	24.35
In winter season:															
November 2008	41	146	26.21	38	84	19.55	32	93	17.07	39	152	28.06	28	74	21.20
December 2008	33	124	22.26	27	71	16.52	28	91	16.71	30	131	24.18	21	68	19.48
January 2009	26	96	17.20	18	58	13.50	22	52	9.55	26	117	21.60	17	60	17.19
February 2009	19	79	14.18	14	38	8.84	17	26	4.77	21	88	16.24	11	52	14.89
In summer season:															
March 2009	14	58	10.41	8	31	7.21	8	25	4.59	16	56	10.33	8	49	14.04
April 2009	9	34	6.10	6	20	4.65	7	22	4.04	11	38	7.01	4	34	9.74
May 2009	5	9	1.61	3	7	1.62	2	7	1.28	7	11	2.03	0	6	1.71
June 2009	11	25	4.48	11	21	4.88	9	28	5.14	12	36	6.64	3	19	5.44
Total	**293**	**1006**	--	**243**	**658**	-	**215**	**665**	-	**255**	**1137**	-	**181**	**600**	-
	1299			**901**			**882**			**1392**			**781**		

M = Male; F = Female